PATENT SPECIFICATION

DRAWINGS ATTACHED

854,222

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COMPLETE SPECIFICATION

Method of Weaving Box-Shaped Fabrics and Articles made thereby

I, EDWARD KOPPELMAN, a citizen of United States of America, of 5300 Pacific, Huntington Park, California, United States of America do hereby declare the invention for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improved box-like structures formed with woven fabrics, to a novel unitary woven fabric conformable to a box-like shape, and to improved methods of weaving such fabrics.

Boxes or box-like structures formed of thermoplastic or thermosetting plastic material reinforced with woven fabric are advantageous for many uses since they may be made relatively strong and of light weight, and are moisture and corrosion resistant to a high degree. In order to provide maximum strength and to reduce the cost of production of such structures, however, it is desirable to provide woven reinforcing fabrics of unitary structure and conforming relatively closely to the final shape of the molded articles. Heretofore, since such shaped fabrics have not previously been commercially available, fabric reinforced plastic articles had to be laid up with flat fabric laminae, which occasioned many process difficulties in the making of shaped articles due to the difficulty of fitting flat fabrics to shaped mandrels and holding them smoothly in position during the subsequent curing of the plastics. The lack of continuity of the fabric laminae not only made the lay up difficult, but also limited the final strength of the article, and due to the possibility of slippage between the laminae during curing of the plastics made matched molding techniques impracticable.

The present invention relates primarily to weaving of fabrics shaped to conform to cuboidal or other similar, flat sided, box-like contours, which fabrics are especially advantageous for use in reinforcing plastic articles, providing improved strength therein, with the attendant advantage that matched metal molding techniques may be used to cure the plastics. Fabrics woven according to the invention are unitary and may be made of uniform density throughout, or, if desired, predetermined portions of the fabrics may be specially reinforced, or the density may be controlled in a predetermined manner according to the strength and other characteristics desired in different portions of the finished product. When used for reinforcing molded plastic articles, fabrics according to the invention may be simply slipped upon mandrels, like socks, saturated with raw liquid resin, or otherwise impregnated with a thermoplastic or thermosetting plastic material and then heated and pressed between mating dies to cure the resin or other thermoplastic or thermosetting plastic material.

Accordingly, one object of the present invention is to provide improved methods of weaving fabrics that may be extended to conform to predetermined contours.

Another object is to provide improved methods of weaving box-like shaped fabrics.

Another object is to provide improved fabrics of uniform, or of controllably varying density that may be extended to conform smoothly to a box-like contour, either completely enclosed or having one or more open sides.

Still another object is to provide improved molded articles of box-like contour formed from thermoplastic or thermosetting plastic material and including reinforcing woven fabrics molded therein that are shaped to conform to the articles and extend continuously around the linear corners thereof.

These and other objects are accomplished by the present invention according to which shaped fabrics are woven flat in folded form upon a Jacquard loom or other weaving apparatus providing individual control of the warp ends. A multi-ply warp is used and the separate plies of the warp are woven together along predetermined lines, at least one of which lines extends diagonally across the

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warp. Fabrics conforming to many different flat sided shapes may be woven according to the invention upon a flat loom using a multiply warp, the separate plies being joined together along lines defining edges thereof to form a unitary fabric. The weaving method somewhat resembles conventional bag weaving processes, except that the warp plies are joined together along a line extending diagonally across the warp, and in some instances the fabric may be woven in more than two layers.

Fabrics according to the invention may be generally characterized as conformable to a corner defined by three intersecting planes, and including woven threads extending continuously around each one of the three edges defined by the different pairs of the three planes. These threads, when the fabrics are extended are bent only at one or more of the following places: adjacent to their ends, at the edges of the fabric, and/or along a line bisecting an angle between two of the edges defined by intersecting planes. Except for such bends and the normal weaving configuration, these threads lie substantially flat and straight.

The fabrics facilitate the lay-up in the manufacture of fabric reinforced plastic articles since they may be fitted upon mandrels quickly and by relatively unskilled personnel. Moreover, the fabrics lend improved strength to the finished articles in which they are molded since they extend continuously around all of the corners of the articles without sewed seams, overlaps, or other discontinuities at the corners. The fabrics may include reinforcing fins woven integrally therein to reinforce the plastic articles at places of greatest stress.

The invention will now be described in greater detail in connection with the accompanying drawings of which:

Figure 1 is a partly schematic front elevational view of a Jacquard loom illustrating one apparatus suitable for use in the practice of the invention;

Fig. 2 is an isometric view of a woven fabric box according to the invention;

Fig. 3 is an isometric view of the fabric box shown in Fig. 2, illustrating the first folding step to reduce the box to a substantially flat form;

Fig. 4 is a plan view of the fabric box shown in Figs. 2 and 3, showing the box after it has been reduced by folding to the substantially flat form in which it is woven;

Fig. 5 is a longitudinal section of the folded box shown in Fig. 4, taken along the section line 5—5 thereof;

Fig. 6 is a cross section of the folded box shown in Fig. 4, taken along the section line 6—6 thereof;

Fig. 7 is an isometric view of a fabric box according to a second embodiment of the invention;

Fig. 8 is a plan veiw of the fabric box shown in Fig. 7, showing the box folded and reduced to the substantially flat form in which it is woven;

Fig. 9 is an isometric view of a fabric box according to a third embodiment of the invention, showing the box in a partially open or extended form;

Fig. 10 is an isometric view of the fabric box shown in Fig. 9, illustrating the initial folding steps to reduce the box to a substantially flat form;

Fig. 11 is a cross-sectional view of the box shown in Fig. 10, but illustrating the final folding step, and showing the box in its substantially flat form;

Fig. 12 is an isometric view of a fabric box of generally similar shape to the fabric box shown in Figs. 9, 10 and 11, but illustrating a modified plan of folding it to a substantially flat shape to provide an increased number of diagonal fold lines and to weave the fabric box without any fold lines extending perpendicularly to the direction of the warp;

Fig. 13 is an isometric view of a shaped fabric according to the invention, showing the fabric being fitted upon a shaped mandrel to which it conforms;

Fig. 14 is an isometric view of a molded plastic box including a reinforcing fabric according to the invention molded therein; and

fig. 15 is a schematic plan view of a portion of a woven shaped fabric according to the invention illustrating one method of reinforcing corners that extend transversely across the warp.

The practice of the invention may be most simply described by first considering a typical example of a fabric woven according to the invention such as the cuboidal, open topped, box-like bag 10 shown in Fig. 2, The height of the side walls 12 and 13 of this bag is about equal to but not greater than the width of the bottom 14. One side wall 12 may be folded flat towards the bottom 14 of the bag to reduce the bag to a prismatic form as indicated in Fig. 3, the end walls 16 and 18 being folded diagonally upon themselves and being reduced to right triangular form. The bag may now be folded flat by folding the second side wall 13 down upon the first side wall 12, again diagonally folding the end walls 16 and 18 as shown in Figs. 4, 5 and 6. It will be seen that now the bag 10 is entirely flat, and the two side walls 12 and 13 lie smoothly on the bottom 14 forming a central portion of rectangular shape. The end walls 16 and 18 have been twice folded diagonally upon themselves and lie flat in four thicknesses of fabric.

The bag may be woven in this folded form upon a Jacquard loom such as the loom 24 shown in Fig. 1 or upon any other weaving apparatus in which the individual ends of a warp may be separately raised and lowered. The warp (not separately designated) is threaded in four plies, i.e., four warp ends are threaded through each dent space of the

reed 26. A separate heddle is preferably provided for each individual warp end in order to provide maximum control to form the diagonal fold lines 28 (Fig. 4) as straight as possible. At the start of the weaving, at least a few warp ends of all of the plies near the center of the warp are preferably woven together to form a relatively dense and rigid fabric tab, or fin 29 (Fig. 4) which serves as a base for weaving the shaped portion of the fabric according to the invention. Only a few picks need be woven in this tab. All of the warp ends except three or five at the center of the warp are then dropped from the weave for the first pick made in the shaped portion of the fabric.

Additional warp ends are progressively added to the weave on subsequent picks, adding from the center outwardly toward both edges of the warp to broaden the fabric along the diagonal fold lines 28. The warp plies are separately shedded in a predetermined sequence so that the flat woven fabric may be unfolded to conform to a box-like contour as illustrated in Fig. 2. Before each sweep of the reed, the shuttle is passed first through the top ply, then back through the bottom ply, then again in its first direction through the lower intermediate ply, and finally returned to its starting place through a shed formed in the upper intermediate ply. Thus the film thread is woven sequentially through all the plies to join them together along lines defining edges of the woven fabric plies.

When the weave has been broadened to its full desired width corresponding to the width of the bottom 14 of the box, weaving of the central rectangular portion is begun. In this portion, the shedding and shuttle passage sequence may be exactly the same as when weaving the triangular end portions, in which case a fully enclosed box-like fabric will be woven, or, as in the example illustrated, the warp ends constituting the upper intermediate layer or ply may be held flat and not formed into a shed upon the final traverse of the shuttle, so that the upper intermediate ply of the warp will not be woven, but may be readily trimmed away after the fabric is finished. In this case, the fabric may be extended to form an open topped box as shown in Fig. 2, and the upper edges of the side walls 12 and 13 may have woven selvedges.

After the central rectangular portion of the fabric has been completed, the second triangular end portion is woven in an exactly analogous manner to the weaving of the first triangular portion, the warp ends being progressively dropped from the weave in the reverse order from that in which they were taken up initially. After the second triangular end portion is finished, another short tab (not shown) of relatively dense rigid fabric similar to the tab 29 is preferably woven to lock the triangular tip and to form a base for weaving another shaped section of fabric.

The system of punching the Jacquard cards to control the weaving according to the methods herein described will be apparent to those skilled in the art of weaving, and does not require detailed explanation herein. Any experienced Jacquard designer will be capable of laying out the Jacquard card sequence required once the desired patterns and shapes of the fabrics are known. Similarly, experienced weavers will be able to set up a warp and to thread and adjust a loom to accomplish the ends herein described without further detailed instructions.

The relatively dense and rigid fabric tabs 29 woven immediately adjacent to the ends of the triangular portions of the shaped fabric may be trimmed off after the fabric is woven, or alternatively, they may be retained and folded flat against the end walls of the fabric for extra reinforcement if desired. The dashed diagonal lines 30 shown on the end walls 16 and 18 of the box 10 shown in Fig. 2 represent lines along which the separate warp plies are joined during weaving, and are the lines along which the warp ends are selectively dropped from or included in the weave as the triangular end portions are woven. Those portions of the warp ends that are not included in the weave, i.e., the floating portions, are severed from the fabric close to the diagonal lines 30 after the fabric is woven, but preferbly the fabric is not trimmed too closely. In order to provide maximum strength in the finished fabric, the warp ends that terminate at the diagonal lines 30 are preferably left a little longer than their woven lengths so that they project slightly from the fabric and hold the fill threads firmly in place. The projecting tips of the warp ends form small ridges such as the ridges 31 shown in Fig. 13, extending along the diagonal lines 30. These ridges normally are folded flat against the fabric when the fabric is molded in a plastic article and provide additional reinforcement. If such ridges are not desired, the warp ends may be severed immediately adjacent to the diagonal lines 30, at some sacrifice in strength since then the fill threads will not be as securely held in position along these lines.

Box-like fabrics may be woven according to the invention folded according to many different plans. For example, if the fabric is to be woven in the form of an open topped box having a height less than half its width, such as the fabric box 34 shown in Figs. 7 and 8, it may be woven from a two-ply warp. The end walls 36 and 38 of such a fabric may be folded, for example, along the diagonally extending lines 40 when the side walls 42 are folded flat against the bottom 44. If the height of the box is substantially equal to one half of the width of its bottom 44, the end walls 36 and 38 form triangular sections when they are folded, and reinforcing tabs (not shown)

are preferably woven at apices as heretofore described. If, however, the height of the box is substantially less than half its width, as illustratively shown, a sufficient number of warp ends are included in the central portion 46 of the weave so that no reinforcing tabs are needed. Such reinforcing tabs are generally desirable only when the folded shaped fabric tapers down to a sharp point at which the diagonal ply-joining lines meet.

Two alternative folding arrangements are illustratively shown in the drawings for weaving open topped box-like fabrics that may be higher than they are wide. The folding scheme shown in Figs. 9, 10 and 11 may be used to advantage where it is desired to provide reinforcing fins along a pair of opposite walls of the extended fabric. In this case, the fabric 50 is folded by pulling the center of the end walls 52 outwardly, folding the walls 52 along their centre lines 54 and then folding the bottom 56 in half, with its center 58 extending upwardly so that the side walls of the fabric are flat and the bottom forms an inverted V, the opposite legs of which are connected to opposite ones of the side walls 60. In this case, diagonal folds 64 are formed in the end walls 52 near the lower ends thereof.

The fabric 50 is woven with the warp extending parallel to the bottom 56, generally horizontally as indicated by the arrow 61 in Fig. 9. A four-ply warp is used, two of the plies being used to form the major parts of the end walls 52 and the side walls 60, and the other two plies being used to form the bottom 56 and the folded under, triangular portions 67 of the end walls 52. The outer plies of the warp, which form the side and end walls meet and are woven together along the lines 54, which extend transversely across the warp and longitudinally along the centers of the end walls 52 when the fabric is extended. To reinforce the end walls 52 these outer warp plies are preferably interwoven outwardly from the end walls 52 to form fins 66. The fins 66 are not only serve to tie the two outer warp plies firmly together, but also provide additional reinforcing strength in a plastic article in which the fabric is molded. The central fold line 58 of the bottom is preferably arranged close to the center line of the loom, i.e. the fabric itself is not necessarily centered in the loom, but extends further toward the side of the loom adjacent to the open end of the fabric in order to maintain uniform tensioning of the fill threads.

Besides the reinforcing fins 66 that extend longitudinally along the end walls 52 of the fabric box 50, additional fins may readily be woven along the lower corners of any of the fabric boxes according to the invention. One corner reinforcing fin 68 is illustrated in Figs. 9, 10 and 11 extending along one corner 69 of the fabric box 50, and similar fins may be provided as desired along any or all of the corners that extend parallel to the warp.

The corner reinforcing fin 68 may be formed by interweaving the warp plies that are joined at the corner 69 transversely outwardly a desired distance from the corner. The fin 68 is rectangular in shape and may be folded smoothly against the bottom or side of the fabric box when it is molded in a plastic article. Ordinarily, the mating dies in the matched metal molding process will automatically fold the fin 68 flat without twisting, especially if it is made relatively narrow.

The corners extending perpendicularly to the warp may also be reinforced if desired by weaving extra warp ends into the fabric for a predetermined distance on each side of those corners as illustrated, for example, in Fig. 15. In Fig. 15, the dashed line 82 indicates the line along which the fabric 84 is to be bent to form a linear corner when it is extended. The normal warp ends 86 extend along the entire length of the fabric ply, and the reinforcing warp ends 88 are woven only for a short distance across the line 82.

The extra ends 88 may be supplied from a separate, auxiliary warp ply, or if the count of the weave permits they may be carried in the principal plus. In either event, however, they are woven only around the corner line 82, and their unwoven portions are preferably severed and discarded when the fabric is prepared for use.

The folding plan illustrated in Fig. 12, similarly to the plan shown in Figs. 9 to 11 is suitable for weaving open top, box-like fabrics in which the height may be greater than the width. It will be seen from the drawing that this folding plan is somewhat similar to the plan shown in Figs. 9 to 11, except that the end walls 52 are collapsed inwardly and their center lines 54 are swung downwardly to lie immediately adjacent to the center fold line 58 of the bottom wall 56. This produces extra diagonal folds 78 extending across the end walls 52 and, depending on the height of the fabric box 70, also across the side walls 60.

The directions of the warp and fill threads in this fabric box 70 are the same as in the immediately preceding example, but no fins comparable to the reinforcing fins 66 need be woven. The outer warp plies are joined to the inner warp plies along the diagonal fold lines 78, instead of along the end wall center lines 54 (Figs. 9 and 10) which in the fabric box 50 extend perpendicularly to the warp direction.

The fabric box 70 may be woven in folded form according to the invention using a four-ply warp, each one of the plies extending the full width of the fabric, i.e., across the full height of the folded fabric box. The shedding sequence is controlled so that the fill thread extends on each pick in a continuous path

through all of the plies, For example, starting at one of the front diagonal fold lines 78 of the folded fabric as viewed in Fig. 12, the shedding sequence may be controlled so that the fill thread extends as follows:

(a) downwardly along the front side wall 72 to the lower linear corner 69,

(b) then around the corner 69 and upwardly through the front intermediate ply to the bottom fold line 58,

(c) downwardly along the rear intermediate ply to the opposite lower corner 71 (indicated in Fig. 11),

(d) upwardly along the rear side wall 73 to the rear diagonal fold line 78,

(e) downwardly along the rear intermediate ply to the end wall center line 54, and;

(f) around the side wall center line 54 and upwardly through the front intermediate ply to the starting point on the front diagonal fold line 78.

The warp is arranged in the loom so that the center fold line 58 of the bottom 56 of the fabric and the folded-in center lines 54 of the end walls lie along the center line of the loom with respect to the shuttle travel in order to maintain proper tension on the fill threads.

Other specific folding methods may be devised according to which fabric boxes of different sizes and shapes may be made. The choice of the particular folding plan to be used in any one instance will depend not only upon the proportional dimensions of the fabric box to be woven, but also upon the strength requirements of the different wall portions of a fabric. It may also be pointed out that the practice of the invention is not limited to the use of any particular materials, but is equally advantageous for weaving fabrics of glass fibers, rayon, cotton, wool, metal wires or any other material capable of being reduced to thread-like form and woven into a fabric. Where maximum strength is desired, glass fiber staple or filament yarns may generally be recommended.

Fig. 13 illustrates the lay-up procedure for making fabric reinforced plastic articles according to the invention, and a finished molded plastic article 92 is shown in Fig. 14. It will be seen that the fabric 70, which is illustratively shown as woven according to the pattern shown in Fig. 12, is merely pulled over the mandrel 90 and fits smoothly thereon, conforming to the mandrel without folds, tucks, or seams. The fabric 70 may be saturated with a raw, or uncured plastic either before or after it is fitted on the mandrel 90. Advantageously, the fabric may be saturated with raw plastic as it comes from the loom and the plastic may be partially cured before the shaped fabric sections are severed one from another. The partially cured plastic then acts as a size to assist in holding the warp ends and fill threads in their desired positions along the diagonal ply-joining, or fold lines when the floating warp ends are severed. The advisability of this procedure, however, will depend largely upon the nature of the plastic to be molded and particularly upon its molding characteristics. The fabric is of relatively uniform thickness throughout, and is securely positioned on the mandrel so that matched metal molding techniques may be used with advantage as to both processing cost reduction and improved properties of the molded articles. As many thicknesses of fabric may be used as desired depending on the nature of the weave, the strength required in the molded article, and the wall thicknesses desired. Final curing of the plastic of all the layers may be done simultaneously in a single processing step producing an integral structure.

Fabrics according to the invention may be woven of relatively uniform density throughout, or, if desired, the density may be varied by any known means such as by weaving in extra warp ends during portions of the weaving or by using different fill yarns in different portions of the fabric to control its density as desired. The weaving pattern may also be varied as desired and each of the warp plies referred to in the description herein may itself consist of several plies either interwoven or separate.

There have thus been described improved methods of weaving shaped fabrics smoothly conformable to box-like contours without folding, cutting, or uneven stretching. The fabrics may be used to special advantage in the plastics industry for reinforcing molded plastic articles, providing increased strength in the molded articles and effecting economies in their manufacture.

WHAT I CLAIM IS:—

1. Method of making a fabric conformable to a corner defined by three intersecting planes comprising shedding a plurality of warp plies separately and inserting fill threads into said warp plies so as to untie the plies along predetermined lines, at least one of which extends diagonally across the warp, and thus to form a unitary fabric.

2. The method as claimed in claim 1 wherein the woven fabric is severed transversely to the warp direction.

3. The method as claimed in claim 1 or 2 wherein another of said predetermined lines extends along one edge of the warp plies.

4. The method as claimed in any preceding claim wherein a two-ply warp is woven into tubular form and the fabric is severed longitudinally along one edge of said warp.

5. The method as claimed in any preceding claim wherein the fabric is woven to conform to a generally box-like shape having an open top, said method comprising individually controlling the ends of said warp, said fabric being symmetrically tapered at both ends by selectively adding and dropping warp ends to and from the weave along substantially

straight lines extending diagonally across said warp, weaving a relatively straight generally rectangular portion in one ply of fabric between the tapered end portions thereof, and leaving a central generally rectangular portion of another ply of said fabric unwoven.

6. A method of making a fabric wherein the fabric is woven with a four-ply warp to conform to a generally box-like contour, said method including separately shedding the different plies of said warp during the said weaving, connecting said plies together along said predetermined lines defining edges of the woven plies by laying the filling in the separate sheds in a predetermined sequence, individually controlling the warp ends, progressively adding warp ends to the weave at the beginning of said weaving to widen the fabric symmetrically along diagonal ones of said predetermined lines, thereafter weaving a rectangular portion of said fabric, and after said rectangular portion is woven selectively dropping warp ends from the weave to narrow said fabric symmetrically along diagonal ones of the said predetermined lines.

7. The method as claimed in claim 5 including weaving the entire width of one ply of said warp between longitudinal pairs of said predetermined lines.

8. A fabric woven in one piece conformable to a corner defined by three intersecting planes and comprising threads woven therein extending continuously around each of the three edges defined by different pairs of said planes when said fabric is conformed to said corner, said threads being curved at the edges of said fabric, and extending along lines parallel to said edges defined by the intersect planes when said fabric is so conformed.

9. A fabric as claimed in claim 8 wherein the fabric extends continuously in a single thickness around each one of the edges.

10. A fabric as claimed in claim 8 comprising a hollow angular shaped body in which the directions of the warp and fill threads in one of the planes change at a line bisecting the angle formed in the plane by the lines of intersection with the other two planes.

11. A fabric as claimed in claim 10 comprising a hollow rectangular shaped body formed of four planes, the diagonals of one of the planes intersected by the other three planes defining lines at which the directions of the warp and fill threads change.

12. A fabric as claimed in claim 10 comprising a hollow rectangular shaped body formed of five or six planes, the diagonals of two opposite planes defining lines at which the directions of the warp and fill threads change.

13. A fabric as claimed in any of claims 8 to 12 which is provided with a fin-like projection extending from a wall of said fabric when it is conformed to said contour.

14. An article of box-like shape made up from fabric woven according to the method claimed in any of claims 1 to 7 wherein the edges of the article defined by intersecting planes are reinforced with thermoplastic or thermosetting plastic material.

15. Method of weaving fabric substantially as herein described with reference to the accompanying drawings.

16. An article produced from fabric woven according to the method claimed in any of claims 1 to 7 or claim 15.

J. A. KEMP & CO.,
Agents for the Applicant.

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854,222 COMPLETE SPECIFICATION

3 SHEETS

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SHEET 1

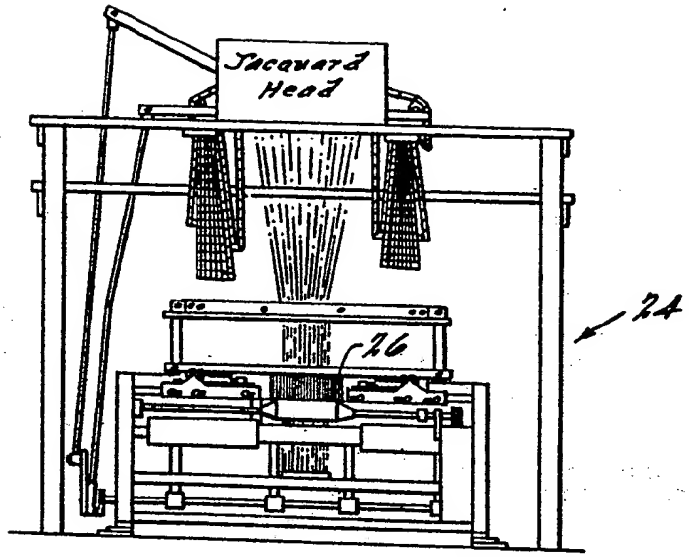

FIG. 1.

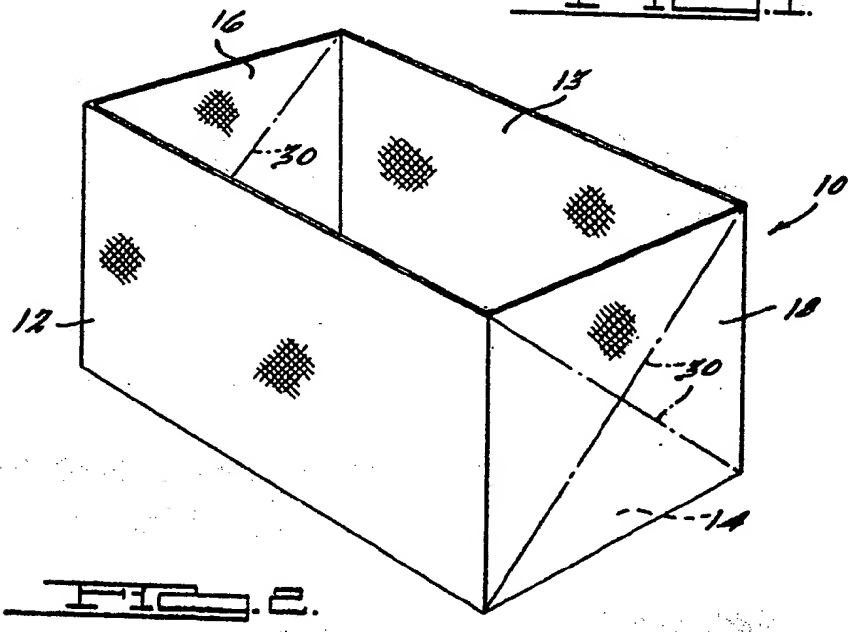

FIG. 2.

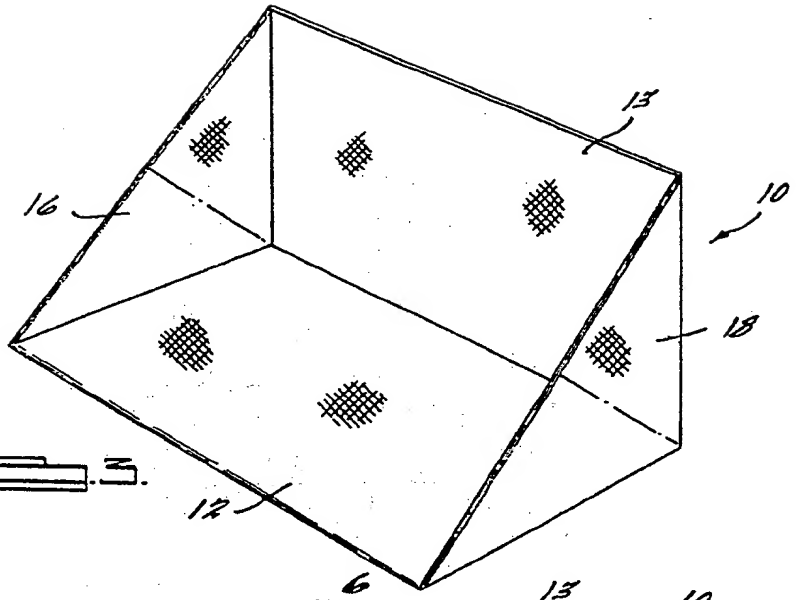

FIG. 3.

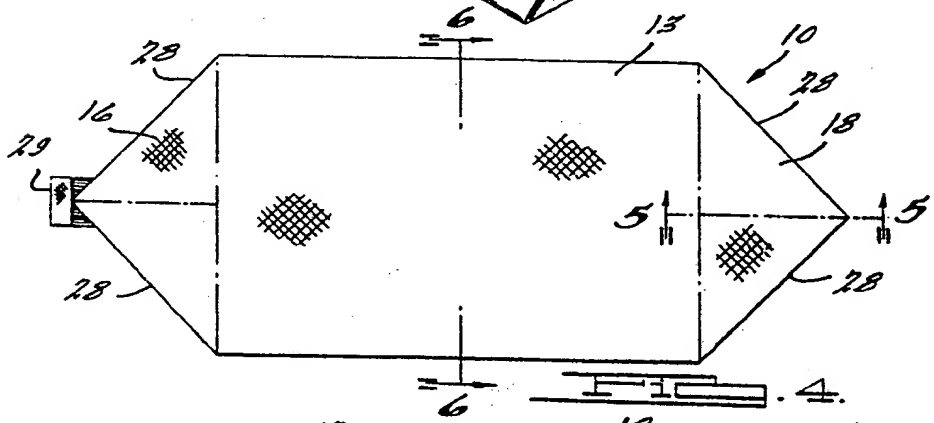

FIG. 4.

FIG. 5.

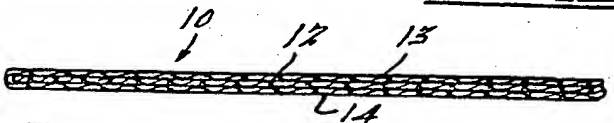

FIG. 6.

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SHEETS 2 & 3

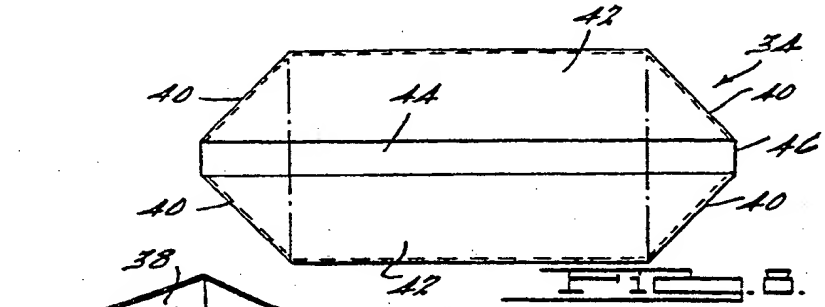


FIG. 8.

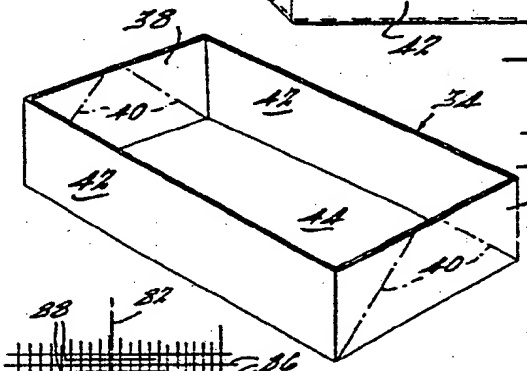


FIG. 7.

FIG. 9.

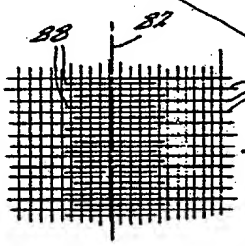


FIG. 15.

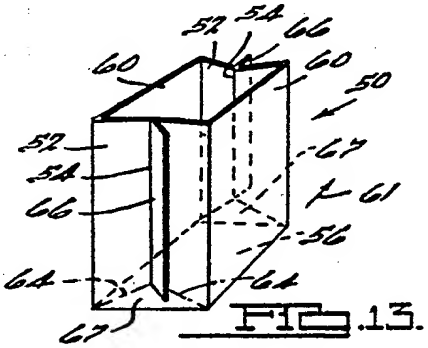


FIG. 13.

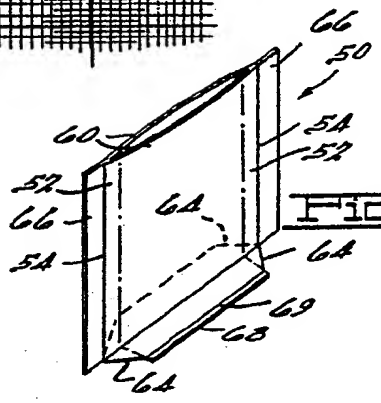
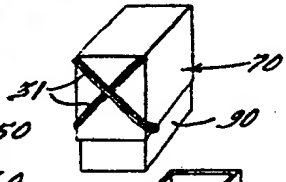


FIG. 10.



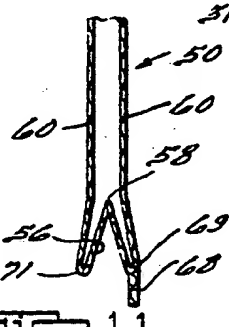


FIG. 11.

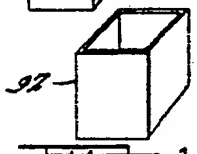


FIG. 14.

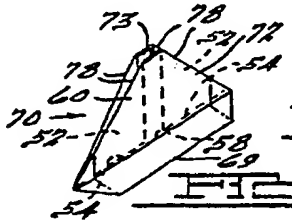


FIG. 12.

854,222 COMPLETE SPECIFICATION
3 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEETS 2 & 3

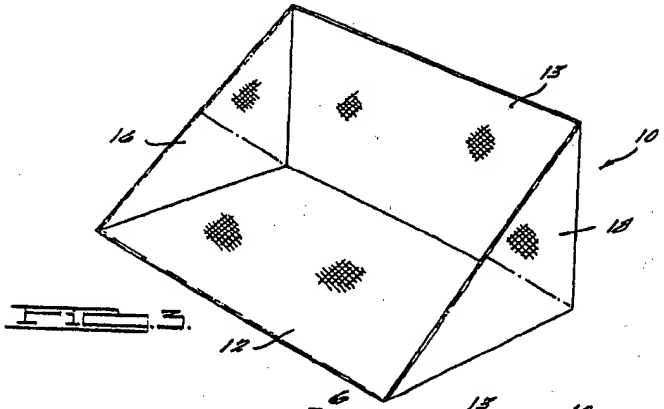


FIG. 3.

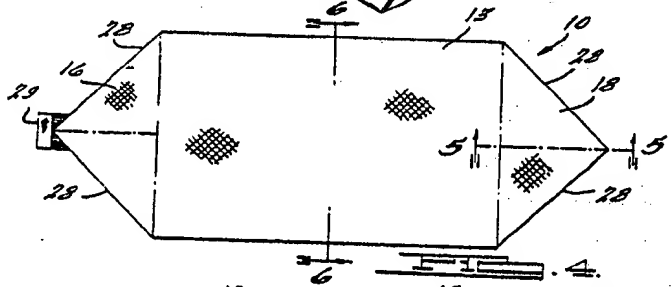


FIG. 4.

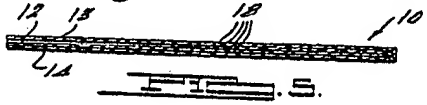


FIG. 5.

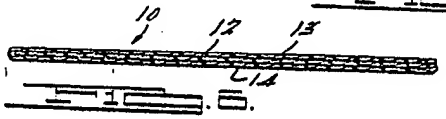


FIG. 6.

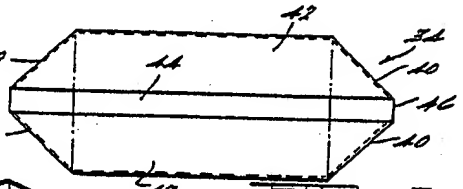


FIG. 8.

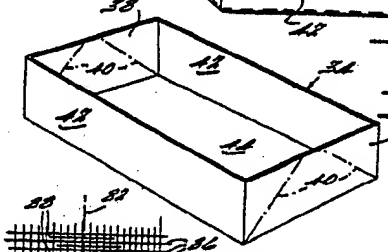


FIG. 7.

FIG. 9.

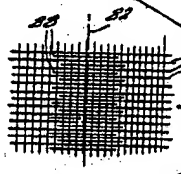


FIG. 15.

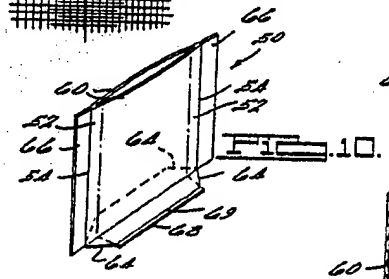


FIG. 10.

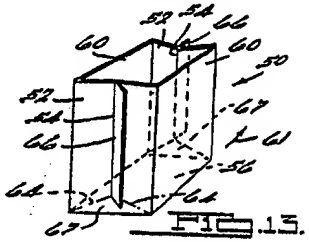


FIG. 13.

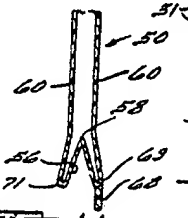


FIG. 11.

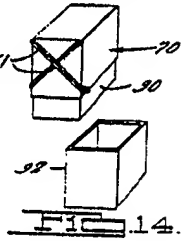


FIG. 14.

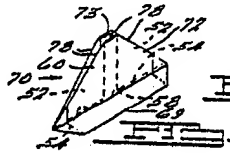


FIG. 12.